VIRGINIA DEPARTMENT OF TRANSPORTATION

ASSET MANAGEMENT DIVISION

STATE OF THE PAVEMENT – 2006

INTERSTATE AND PRIMARY FLEXIBLE PAVEMENTS

VIRGINIA DEPARTMENT OF TRANSPORTATION

State of the Pavement – 2006

Interstate and Primary Flexible Pavements

By

Central Office

Asset Management Staff

October 2006

EXECUTIVE SUMMARY

This report describes the condition of asphalt pavements on Virginia's Interstate and Primary highway systems based upon data collected, processed and analyzed during 2006. Similar reports have been issued on an annual basis since 2002.

The information in this report can be used to understand variations in pavement condition by route type, maintenance district and county. This information is used to budget for and prioritize pavement maintenance needs. It also aids the day-to-day maintenance activities of the agency, especially in the development of resurfacing schedules.

This report provides extensive background information on methods and processes for data collection, quality assurance, derivation of condition measures, and the use of pavement condition measures to assess deficiencies and needs. An important objective of this report is to encourage wide review of this information and feedback from users. This feedback will be used to make continued improvements to the pavement management program and the Asset Management System.

The report is organized into three major divisions: data collection, 2006 pavement conditions, and uses of pavement condition information. Appendices provide details on the condition indices used and on county-by-county pavement condition. The major features of each section are summarized below.

PAVEMENT CONDITION DATA COLLECTION

The pavement condition data presented in this report were collected using a windshield survey approach; a method that has been used consistently over the past six years. Starting in 2007, VDOT will shift to an automated pavement data collection method utilizing specially equipped vans. This method was piloted for Interstate highways in 2005 (in parallel with the windshield surveys), and the technology was found to produce acceptable results in a highly efficient manner.

The current windshield surveys are conducted by teams of three trained raters. Raters follow well-defined procedures that are documented in the VDOT *Distress Rating Manual.* [1] Given the subjective nature and inherent variability of windshield surveys, diligent quality assurance procedures have been implemented. The quality assurance process for 2006 involved the statistically valid random sampling of the rated sections in each district followed by the evaluation of those samples by an independent two-person QA team. This process assured that production teams rated in a standard manner and that any statistically significant differences in the collected data between districts are real differences.

Raw distress data collected in the field is aggregated into two Pavement Condition Indices. The Load-related Distress Rating (LDR) incorporates pavement distresses that are related to traffic loadings (for example, longitudinal cracking in wheel paths).   The Non Load-related Distress Rating (NDR), is comprised of distresses considered to be primarily non-load related (i.e., climate, materials or construction deficiency). Both indices range from a value of 0 to 100. A value of 100 is assigned to a pavement with no visible distress, while 0 is assigned to a pavement considered impassable. A third index – the Critical Condition Index (CCI) is calculated as the lower of the LDR and NDR. These indices were first developed in 1998, and have undergone extensive validation through a process of consensus building using numerous VDOT pavement experts. It should be noted that pavement ride quality or roughness (IRI) data is not considered in this report.

As shown in Table I, pavement index values (CCI) have been grouped into five ranges corresponding to condition categories: excellent, good, fair, poor and very poor. These categories in turn correspond to a likelihood of corrective action. In general, pavements with an index below 60 are likely candidates for maintenance and rehabilitation action.

Table I : Pavement Condition Definition

Index Scale (CCI)	Pavement Condition	Likelihood of Corrective Action
90 and above	Excellent	Very Unlikely
70-89	Good	Unlikely
60-69	Fair	Possibly
50-59	Poor	Likely
49 and below	Very Poor	Very Likely

The very poor to excellent classifications probably are more meaningful for those not directly involved in pavement management while the "likelihood" would be more useful to maintenance programming and resurfacing schedule development.

2006 PAVEMENT CONDITIONS

Pavement conditions observed in 2006 throughout the state are presented in terms of the above-mentioned categories and indices. The data comprise a "snapshot" of pavement condition over roughly a four-month period of time in early 2006.

Figures I, II, and III present highlights of the condition results. The main body of this report contains further details, and also includes a separate discussion of pavement maintained by Virginia Maintenance System, Inc. (VMSI).

Figure I shows the breakdown of pavement condition by category within each district. It can be seen that the percentage of poor or very poor pavements (CCI < 60) varies from a high of approximately 20% in district 2 to a low of 9% in districts 3 and 5.

Figure I : Network Condition by District

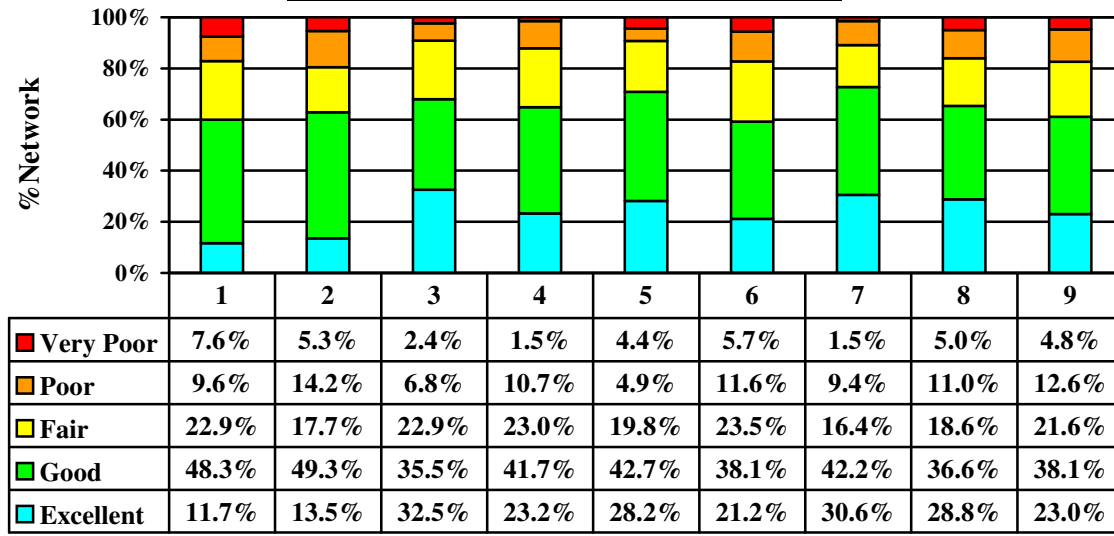|	1	2	3	4	5	6	7	8	9
■ Very Poor	7.6%	5.3%	2.4%	1.5%	4.4%	5.7%	1.5%	5.0%	4.8%
■ Poor	9.6%	14.2%	6.8%	10.7%	4.9%	11.6%	9.4%	11.0%	12.6%
■ Fair	22.9%	17.7%	22.9%	23.0%	19.8%	23.5%	16.4%	18.6%	21.6%
■ Good	48.3%	49.3%	35.5%	41.7%	42.7%	38.1%	42.2%	36.6%	38.1%
■ Excellent	11.7%	13.5%	32.5%	23.2%	28.2%	21.2%	30.6%	28.8%	23.0%

Figure II displays the percentages of deficient (LDR or NDR<60) pavements by county for the entire state. In Figure II, blank spaces represent the urban areas or the cities that are not maintained by the state. While study of the data continues, it is expected that heavy traffic, either volume or loads, will explain many of the regions of high deficiency.

Figure III presents the number of deficient lane miles by district, complementing the percentage distributions shown in Figure I. Three of the nine districts (1, 2 and 8) have over 500 deficient lane miles each and collectively account for almost half of the roughly 3700 deficient miles statewide. Districts 3, 5, and 7 have less than 300 deficient lane miles each. The other three districts (4, 6 and 9) have between 350 and 500 deficient lane miles each.

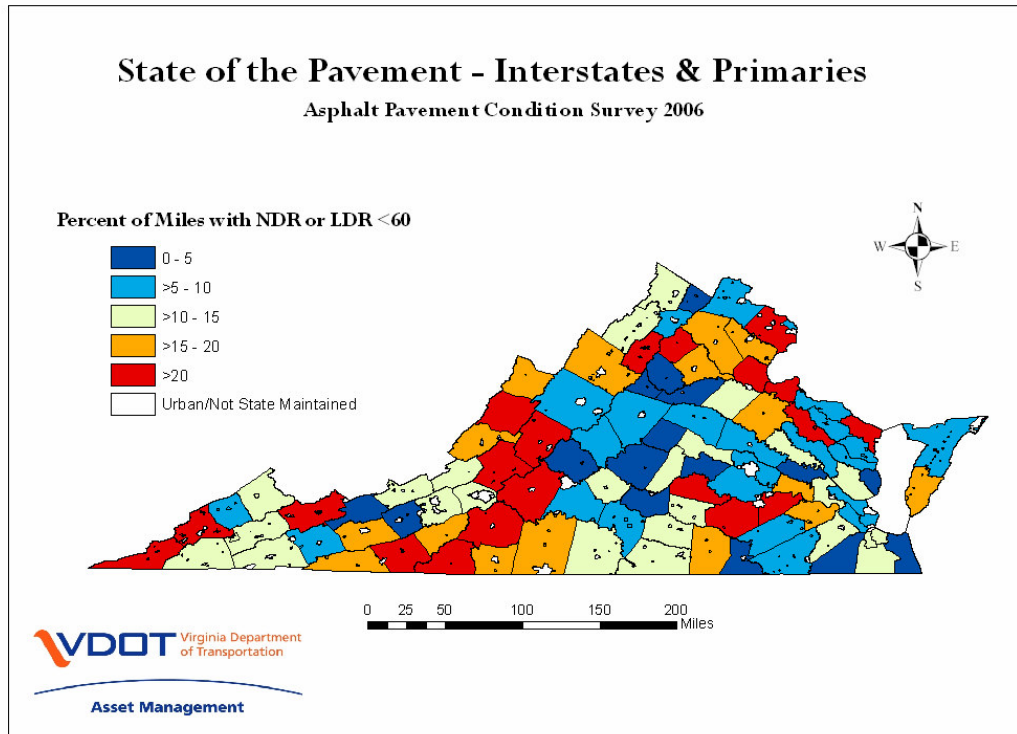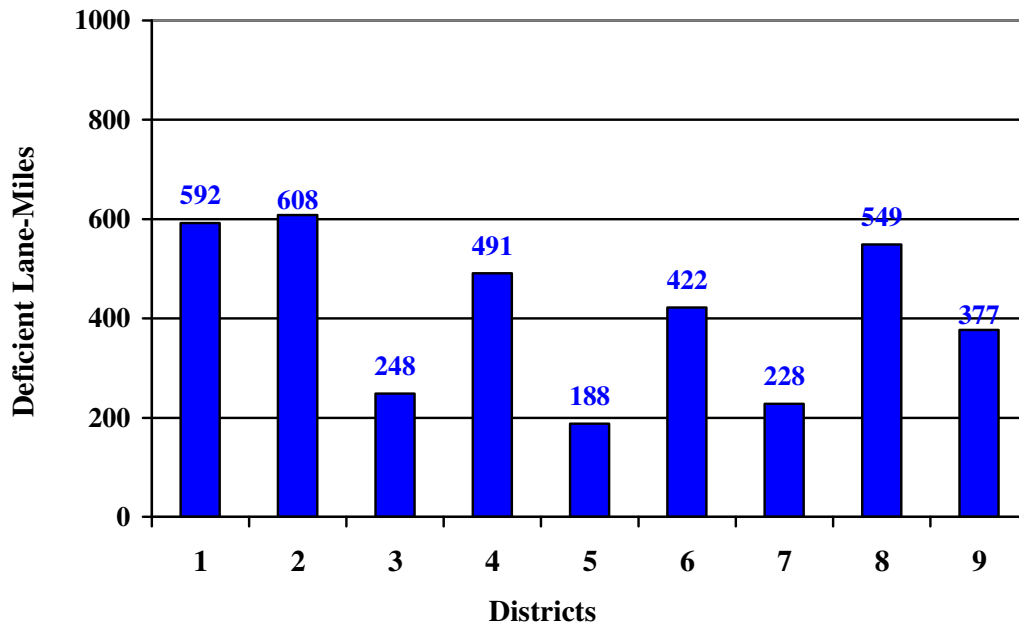## Figure II : Pavement Condition by County

Figure III: Deficient Lane Miles by District (2006)

USES AND LIMITATIONS OF PAVEMENT CONDITION INFORMATION

Pavement condition data is an important input to VDOT's needs-based budgeting and priority programming processes. The Asset Management System uses the pavement condition data to develop estimates of pavement maintenance and rehabilitation needs, which in turn are used to develop the biennial maintenance budget request and to guide the allocation of available funds to districts. Pavement condition data is analyzed via automated decision models to produce initial treatment recommendations that feed into the development of annual resurfacing schedules. Accumulation of consistent, quality condition data over time allows VDOT to develop and refine pavement performance curves used to predict future pavement conditions. It also enables the development of complex cost-benefit analyses, the measurement of maintenance cost effectiveness, the study of the influence of new construction materials on pavement performance, and would serve as a basis for vehicle cost responsibility studies and the establishment of licensing fees related to pavement damage.

Current limitations of the data generally are related to the inherent variability of windshield data due to its subjective nature. This means that managers must accept a degree of uncertainty in decision-making that can be mitigated only through a strong quality assurance program and positive feedback from users of the data.

TABLE OF CONTENTS

STATE OF THE PAVEMENT - 2006

BACKGROUND

The pavement management program in Virginia began with the establishment of a pavement inventory. That phase took place in the 1970s with the manual gathering of pavement records including those of construction history and rehabilitation projects. The merging of those early pavement records and the then existing highway inventory eventually evolved into what is now known in VDOT as the Highway Traffic Records Information/Inventory System (HTRIS). While, as the name implies, HTRIS is heavily oriented toward traffic engineering needs, it also was the first repository for pavement construction and rehabilitation records or pavement inventory. The system was developed and remains a mainframe computer application widely accessible throughout VDOT.

A second stage of pavement management activity in the state took place in the early 1980s and involved the development of a first generation pavement condition assessment methodology. This methodology, used throughout most of the 1980s and early 1990s, was a windshield survey based index procedure called the distress maintenance rating (DMR) with a rating scale of 0 to 100, with 100 being a pavement with no visual surface distress.[2] The procedure gave consideration only to pavement surface distresses with heavy emphasis on cracking and patching. The DMR index was widely used for priority programming of resurfacings and other rehabilitation activities. Unfortunately, the system had major disadvantages, the most critical of which was that it gave no consideration to pavement structural integrity such that the pavement with the worst visual condition rating received the highest priority on a "worst first" basis. In practice, maintenance personnel often recognized this limitation of the DMR and used engineering judgment as an additional tool in scheduling resurfacing and other work. Other disadvantages of the DMR approach, as typical of windshield surveys, was the inherent danger in putting people in harms way to collect the data and the inherent variability associated with such a subjective process. The latter disadvantage was the root of distrust of the procedure for the allocation of funds although there was some early use of the process for those purposes [3].

In the mid-1990s VDOT began to collect pavement distress data through the use of videotaped images. To make use of data collected from those tapes VDOT also made interim use of the pavement condition index (PCI) defined and used by the U.S. Army Corps of Engineers[4]. After several trial years, the PCI was deemed too general for Virginia conditions so that a VDOT specific method, as described in detail in Appendix A, was considered necessary. Briefly, that system recognizes that pavement distresses

fall into two basic categories; they are either load related (caused by the application of vehicular loadings) or they are not load related (caused by the exposure of pavement elements to the environment). This realization gave rise to the development of two indices to describe pavement surface distresses. These are the load related distress rating (LDR) and the non-load related distress rating (NDR). These two indices, also, use 0 to 100 scales and are the basis for pavement surface condition evaluation in VDOT. The indices are described in Appendix A.

The advent of pavement data collection through contracted automated means led to a need for standardization of procedures for the purposes of consistency and as a contractual instrument for bidding purposes. The document providing this standardization, *A Guide To Evaluating Pavement Distress Through The Use Of Digital Images* [1]*,* was developed in the late 1990s and made available to vendors bidding on contract data collection.

Pavement distress condition throughout the state is crucially important information and one of the most important products of the Pavement Management Program. Dissemination of that product throughout the agency is a major reason a 1998 condition report [5], the 2002 report [6], the 2003 report [7] and the 2004 [8] report were assembled. One of the uses of this information is to aid in the day-to-day maintenance activities of the agency. Another value of disseminating this information is to receive feedback from users on the pavement management and the asset management systems. That feedback will be used to identify and address changes that may enhance the continued implementation of the Asset Management System.

PURPOSE AND SCOPE

The present document is intended to provide the reader with an overall assessment of the condition of pavements throughout the Commonwealth. Clearly, there are limitations, as the data used were collected through a windshield process and constitute an evaluation only of surface condition as reflected primarily through cracking and patching. It is, therefore, anticipated that the uses of the data would be limited to priority programming based on a "worst first" basis. Any consideration of structural integrity of the pavements is related to the possibility of deducing structural deficiency from the nature of some distresses (e.g., early alligator or fatigue cracking would suggest a pavement is subject to loadings in excess of its design capacity).

The discussions are limited to asphalt surfaced pavements on the primary and interstate systems. Again, data is limited to surface distress obtained through windshield surveys and does not address ride quality, the commonly accepted indication of public perception of pavement condition. Thus it can be said that the pavement condition data described in this document meets a need of pavement managers, but does not address the major public issue of ride quality.

2006 DATA COLLECTION

Pavement data collection for 2006 consisted of windshield surveys conducted by trained VDOT personnel, most of whom had conducted similar surveys in previous years. After several years of collecting condition data objectively through instrumented vehicles, windshield surveys were re-introduced in VDOT during 1999-2000 when it became apparent that new data collected by those vehicles would not be available in time for the development of resurfacing schedules for 2001. Continuing absence of timely automated data led to a repeat of those surveys in 2001, 2002, 2003, 2004, 2005 and 2006 as background for the development of Fiscal Year 2003, 2004, 2005, 2006, 2007 and 2008 resurfacing schedules, respectively.

The following sections describe the major data items that were collected, the processing that was carried out with this data, how windshield data compares with data collected through automated means, and the results of the 2006 surveys. The 2006 data consists only of pavement surface distresses, as ride (international roughness index, IRI) data requires the commitment of automated equipment not available to the survey teams. A subjective ride quality rating (acceptable or unacceptable) was used in some cases at the discretion of survey teams.

DISTRESS DATA ELEMENTS COLLECTED

Most pavement resurfacing decisions are based on very few considerations. The most common have been judged by VDOT pavement management staff to be severe alligator cracking, excessive patching, excessive rutting, and unacceptable ride quality. These factors and others considered by the windshield raters are summarized in Table 1.

The data elements given in Table 1 are compatible with those reported in the 1998, 2002, 2003 and 2004 condition report. The difference in procedures is that the 2002 through 2006 data were collected through a windshield survey while that for 1998 was from the review of videotapes.

Table 1 also provides a summary of how the distresses were defined and how they were classified with regard to frequency of occurrence and severity. In addition, guidelines on how to count the various distresses are given.

Finally, 2006 data are supportive of the load related distress rating index (LDR) and the non-load related distress rating index (NDR) used in the 1998, 2002, 2003 and 2004 condition report and summarized in Appendix A of the present document. Data included in the 1998 report was collected on video tapes and the distresses determined from those tapes. The 2002 through 2006 windshield survey data collection format was devised so as to be compatible with both the 1998 data and the indices used in that report.

Table 1 : Windshield Survey Condition Factors

Distress/Factor	Severity Levels	Definitions	How To Count
Alligator Cracking (Including sealed cracks)	Not Severe Severe Very Severe	Longitudinal Crack Interconnected Cracking w/o spalling Interconnected Cracking w/spalling	Rare - Less than 10% of pavement area Occasional - 10 to 50% of pavement area Frequent - Over 50% of pavement area
Transverse/Reflection Cracking	Not Severe Severe Very Severe	Visible Crack Open Crack Spalled and/or adjacent cracking	Use Actual Crack Counts
Rutting	Less than ½ inch Or Greater than ½ inch	Consensus of Rating Team (Capable of ponding water)	Rare Or Widespread
Patches	Yes, No	Yes - some patching in section No – no patching in section	Less than 10% of pavement area Or More than 10% of pavement area
Ride Quality	NA	Consensus of Rating Team	Acceptable Or Unacceptable

DATA COLLECTION PROCEDURE

GENERAL

Windshield surveys were conducted on homogeneous pavement sections driven over at approximately 25 mph. Team members were asked to do a mental averaging of pavement condition factors as each section is traversed then to reach a team consensus rating at the end of each section. When contiguous sections were rated, the survey team stopped at the end of each section to do the consensus rating.

Data was collected through the use of notebook computers carried in the rating vans. "Windshield Survey" software developed for the 2000-2001 surveys was used in automating the data collection process. The software reflects the content of the rating form provided in Appendix B. A major change from 2000-2001 year's windshield data collection was in the handling of transverse/reflection cracking. In 2000-2001 surveys, the evaluation of those cracks was based on an estimate of whether there were 10 or more cracks per mile. When trying to compare that data to data collected through automated means, it was determined that "10 per mile" was not an adequate criteria such that actual crack counts now are recorded. This change can have a significant impact on the non-load related distress (NDR) rating. However, that is not a major issue in much of the state where there are few old underlying jointed concrete pavements or where shrinkage prone pavement materials were not used. Another minor change was to collect patching data only on the basis of estimated percentage of pavement area (less than or more than 10 percent). Older procedures provided an option of less or more than 10 patches per mile. The two are clearly not equal as patch size is not an issue where only the count was used.

In the rating software, the algorithms to determine pavement LDR and NDR were programmed so the results of ratings will be immediately available. That immediate availability was considered to be important as it allows the rating team to have an immediate indication of how they "feel" about the rating.

For the purposes of comparison with values computed for the 1998 pavement condition data collected automatically, it is important to note that the definitions of load and non-load related distress indices in the context of the windshield survey are:

LDR = 100 - Deduct_Alligator_Crk - Deduct_Rutting - Deduct_Patching

NDR = 100 - Deduct_Reflection_Crk – Deduct_Transverse_Crk - Deduct_Patching

RATING FORM

Although it was expected that data would be collected on laptop computers with the above-mentioned software, the rating form given in Appendix B was provided as an indication of data format and to be used in the event of a computer breakdown, etc.

RATING TEAMS

The assignment of rating teams for windshield surveys was given special attention, as one of the goals was to avoid any chance of team members exercising a rating bias in favor of their home districts. Rating team assignments were made so nine three-person teams would do the ratings. The major criteria were that no more than one person from the district being rated would be from that district, insofar as feasible team members would not be from immediately adjacent districts, and that the workload be as evenly distributed as possible. Core members of rating teams were the district members of the pavement management engineering team (PMET). The teams were made up of district pavement management engineers (DPMEs), district pavement management coordinators (DPMCs), one district pavement management specialist, and central office pavement management (PMP) personnel. Every team was different and usually comprised of a mix of engineers and coordinators. In addition, no person was asked to serve on more than two teams. Finally, extensive travel was minimized in cases where prospective team members indicated that such travel would create a hardship. A short questionnaire was circulated to determine the availability and assignment preferences of district personnel. The teams as determined from questionnaire results are given in Table B1 of Appendix B.

Training of Rating Teams

The 2000 training was conducted on some 30 sites in the Fredericksburg district. The windshield survey rating teams had been extensively trained prior to the 2000 surveys and a brief refresher session was held prior to the 2001 work, as there were very few changes in personnel between the two years. The 2001 refresher was on 8 sites in the Staunton district. In 2002, it was decided that rating team members were sufficiently competent with rating procedures and that data discrepancies would be detected by the quality assurance (QA) process. The training session held prior to the 2003 survey was focused on individual rater variance/bias and held in the Culpepper district on a total of 12 sites.

In 2004, production rating teams were trained by rating some pre-selected 6 training sites in the Culpepper District. This training consisted of an organized rating of pavements having a wide range of distresses. The procedure and locations were first discussed in a classroom setting. Then, rating teams went into the field, followed the prescribed procedures, and rated pavement sections previously selected for the training. Finally, teams returned to the classroom for a thorough discussion of the rating results. In all the cases, identified differences in procedures or indications of bias were pointed

out to the participants with suggestions for corrections. Training procedures in 2005 and 2006 were similar to the one in 2004. Training in 2005 was conducted in Lynchburg district while the training in 2006 was conducted in Richmond district.

Rating Team Operations

Each rating team operated in a similar fashion with the representative from the district being rated serving as the navigator within his/her district. That individual also was responsible for seeing that the rating team was properly equipped for the work with a van containing a calibrated distance measuring instrument (DMI), a notebook computer with the proper software installed, service vehicle lights, "pavement rating" or similar sign, hard hats, vests, and communications equipment. Other members of the team alternated between driver and recorder by switching responsibilities at mid-day.

QUALITY ASSURANCE

Procedures

Because of the historical distrust of windshield surveys, an independent quality assurance (QA) process is an important consideration. For 2006 windshield survey data, the quality assurance process consisted of evaluation by an independent QA team on randomly sampled sites in each district. A minimum of 20 primary and 10 interstate sections, where applicable, per district were evaluated. The QA team followed the same data collection procedures as the production teams. The same core QA team evaluated all districts so that any bias on the part of a production team or teams would be detected.

Production and QA results for the random samples were analyzed statistically to determine any significant biases and to compare the results of QA and production teams. The results of this analysis are described in the following section.

Quality Assurance Results

Before looking at the condition of Virginia pavements as determined from 2006 survey, it is helpful to examine the quality assurance procedure more closely and to discuss the results of that process.

Two questions are important to the assurance that pavement condition data is generally of value, that it is useful in comparing the relative conditions of various parts of the state, and that it can be used as a tool in the allocation of pavement maintenance/rehabilitation funds. These are:

- Is the data free of bias, i.e., did all raters look at things in the same way and were they able to achieve similar results when rating the same

pavements? A biased team would consistently rate lower or higher than the norm.

- Is the data collection process such that random data error is held to an acceptable level, i.e., is the "measurement" error such that the data are useful? This error is related to variations in pavement lighting, moisture, etc. at the time of rating as well as to how well the rating system itself is structured.

Figure 1: Comparison of QA and Production LDR Values by District
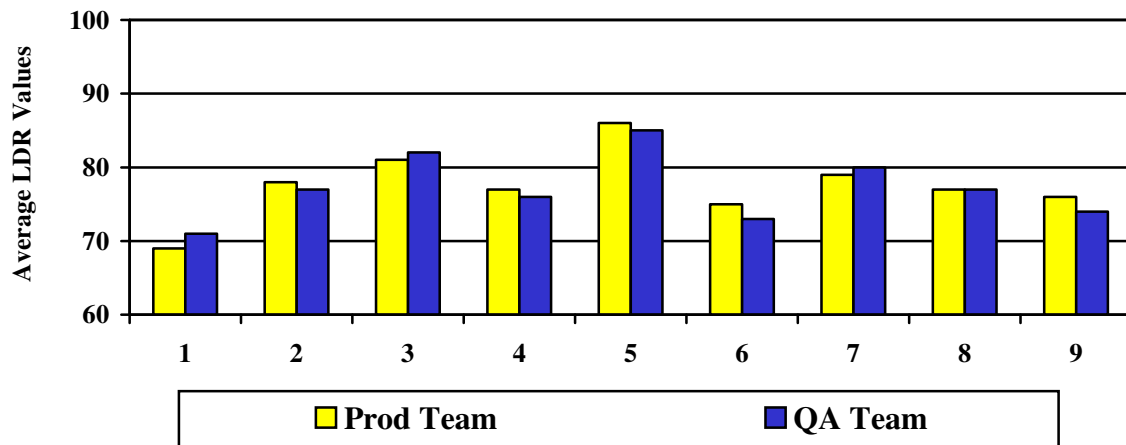
Details of the QA process are given in Appendix C while the results are summarized in Figures 1 and 2. Figure 1 provides a comparison of QA and production LDR values by district. For each district the QA and production values are for the same sites such that for a perfect process the QA and production averages would be exactly the same. Since windshield ratings are inherently variable the two averages differ somewhat for each district. However, those differences are small and none are statistically significant. Also, it is interesting how the QA and production averages track each other extremely well from district to district, i.e., if one goes up the other goes up too.

Figure 2 is a similar comparison for the NDR results by district. It again shows that there are only small average differences between the QA and production teams and that those results track each other from district to district.

Figure 2: Comparison of QA and Production NDR Values by District
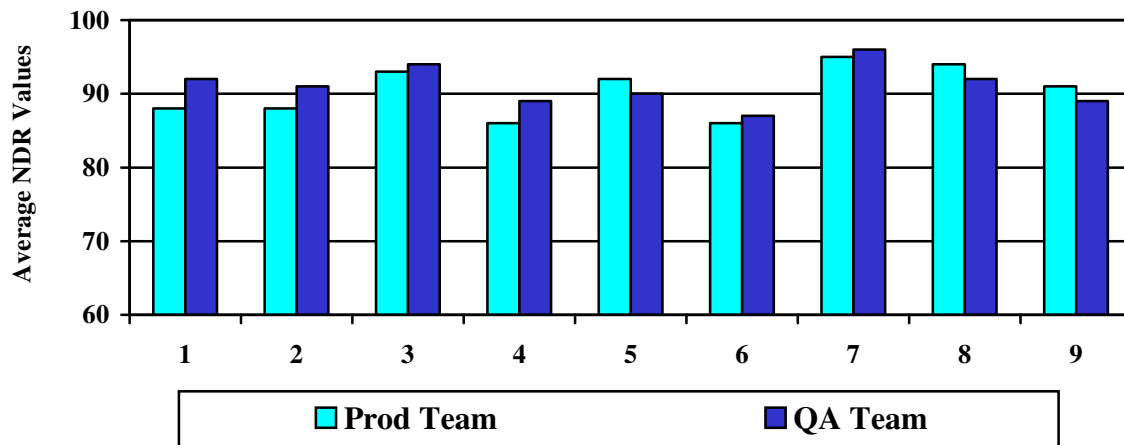
As a whole, the QA process confirms that well trained teams can do windshield surveys in a consistent and reproducible manner such that the ratings in one district can be safely compared with those in another. It also tells us that indicated differences in pavement condition between districts are real such that managers can have confidence in using the data as a planning tool. The data further show that the average of differences between two teams rating the same pavements is less than two index points. Based on the data collected and the QA results, we would expect that observed LDR variation between two teams should be within 21 points, approximately 95% of the time. Experience with windshield surveys have revealed that much of that variability is due to external factors such as the angle of the sun or the moisture condition of the pavement at the time of rating.

We can conclude from the QA process on 2006 windshield surveys that there is no bias between teams and that the inherent variability of the process can be quantified so that the data has real meaning. Therefore, indicated average pavement differences between districts shown later in this report are real differences and not just the result of chance. It follows that the windshield data is a useful pavement management tool for the selection of individual resurfacing and maintenance sites, for the development of budgets, and for the allocation of funds within and among jurisdictions.

2006 PAVEMENT CONDITION

The 2006 windshield surveys began in February and were completed, including the QA evaluations, by early May. The production and the QA data were collected concurrently so that there is no time lag between them. The following sections summarize the inventory evaluated and the results of those surveys, including the establishment of a scale of relative condition evaluation.

PAVEMENT INVENTORY EVALUATED

Windshield surveys were conducted in the rightmost traffic lane, usually designated lane 1 in the VDOT pavement inventory, while the tabulations, graphs, and discussions below were extended to a lane mile basis. For example, a one-mile long pavement section with three lanes in the direction of rating would be reported as three lane miles. To attempt to accommodate situations where there are significant differences between lane 1 and other lanes rating teams were encouraged to note those differences in the "notes" field provided in the rating software.

Using the system described above, approximately 25,452 lanes miles are accounted for in the 2006 surveys. This compares to some 25,479 lane-miles given in the VDOT "Mileage Tables" dated December 31, 2004. The mileages included in the windshield survey for each district are given in Appendix D.

CONDITION EVALUATION CRITERIA

Table 2 provides a scale for evaluation for the 2006 pavement condition survey results. The index scale provided in that table is the result of experience with previous windshield surveys and reflects earlier action of the PMET. The PMET action was a decision that pavements with a condition index of less than 60 would be evaluated further for possible maintenance or rehabilitation. It should be noted that this criteria differs somewhat from that used in the 1998 Condition Report for data collected from videotapes. In that case, the trigger point for additional evaluation was established at an index of 50. The difference in criteria is somewhat subjective, but reflects the judgment of the PMET that for the same conditions pavements rate slightly higher with windshield surveys than with the automated process. Starting with 60 as the dividing point between fair and poor condition, other portions of the scale were established to provide rational levels of condition.

The scale given in Table 2 applies to both the load related index (LDR) and the non-load related (NDR). In subsequent sections where summary statistics of pavement condition are described the procedure followed is that the lower rating controls, i.e., for each pavement section the LDR and NDR values are determined and the pavement condition is classed as excellent, good, fair, etc., depending upon the lowest index. That index is then defined as the critical condition index (CCI). In general, pavements rating less than 60 by either index are considered to be deficient, i.e., they need some kind of attention. The right most column of Table 2 describes in general terms the likelihood a pavement falling into each condition class will be resurfaced or have other corrective action programmed.

Table 2 : Pavement Condition Definition

Index Scale (CCI)	Pavement Condition	Likelihood of Corrective Action
90 and above	Excellent	Very Unlikely
70-89	Good	Unlikely
60-69	Fair	Possibly
50-59	Poor	Likely
49 and below	Very Poor	Very Likely

THE CONDITION OF THE VIRGINIA PAVEMENT NETWORK

Figures 3, 4, and 5 summarize the condition of Virginia primary and interstate pavements statewide by network using the criteria given above. Figure 3 provides a statewide breakdown of all primary and interstate pavements by condition class. Note that, by the criteria established earlier, some 65% of pavements are classed as good to excellent while approximately 15% are considered deficient (poor and very poor condition).

Figures 4 and 5 summarize statewide pavement condition by interstate and primary networks, respectively. These figures reflect similar condition classifications to Figure 3 and serve only to show that interstate pavements are in slightly better overall condition than those on the primary system. The interstate pavements are classified about 66% good to excellent and 10% deficient while those on the primary system are 64% good to excellent and 15% deficient.

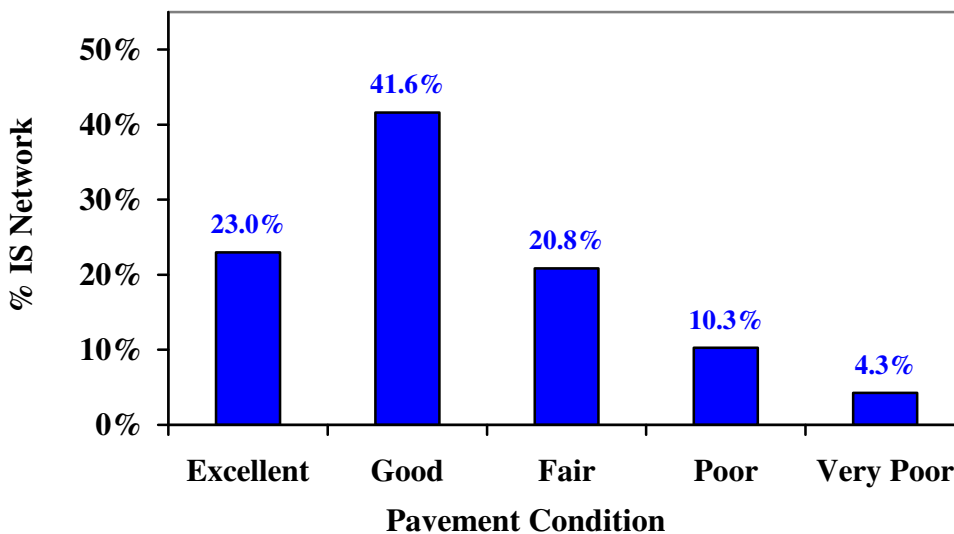## Figure 3 : Condition of the Network (2006) IS and Primary Pavements

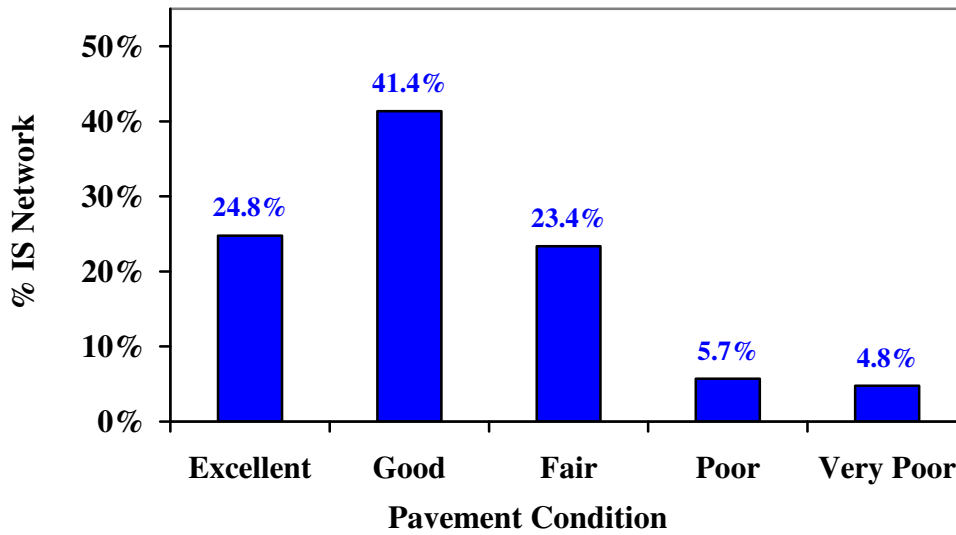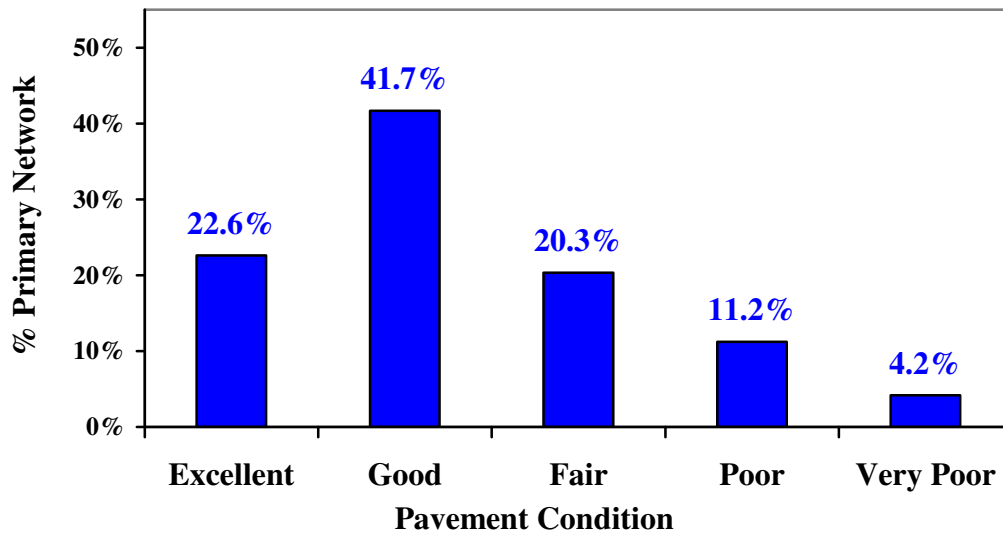**Figure 4 : Condition of IS Pavements (2006)**

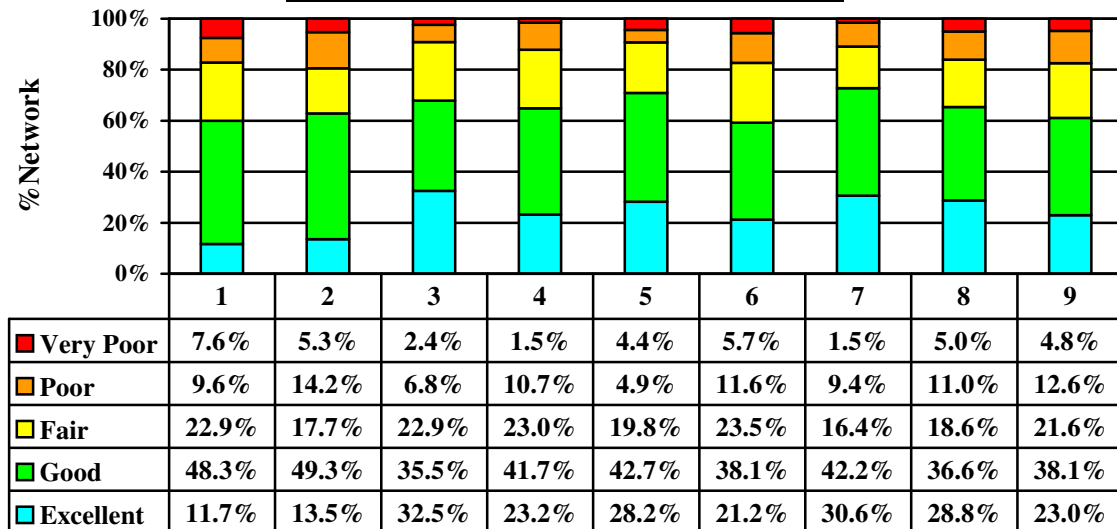**Figure 5: Condition of Primary Pavements (2006)**

   The lane mileages represented by Figures 4 and 5 are approximately 4,400 for the interstate system and 21,000 for the primary. Pavement condition by district and county is discussed in the following section.

THE CONDITION OF VIRGINIA PAVEMENTS BY DISTRICT

   Figure 6 provides a comprehensive breakdown of pavement condition for each of the 9 districts. Again, pavements classified as poor and very poor are considered as 'deficient'. The figure shows that there are some marked differences in pavement condition among the districts.   Note that the deficiency classification ranges from 9% of lane-miles in the Lynchburg and Hampton Roads districts to about 20% in Salem.

   In Figure 7, pavements rated as deficient are given on a lane-mile basis for each district. Because of large differences in inventory managed by the districts, the distribution of needs looks somewhat different on a lane mile basis. Hampton Roads shows the lowest need with 188 lane-miles. Other districts show deficient lane miles from 200 to about 600 lane miles.

Figure 6 : Network Condition by District

	1	2	3	4	5	6	7	8	9
■ Very Poor	7.6%	5.3%	2.4%	1.5%	4.4%	5.7%	1.5%	5.0%	4.8%
■ Poor	9.6%	14.2%	6.8%	10.7%	4.9%	11.6%	9.4%	11.0%	12.6%
■ Fair	22.9%	17.7%	22.9%	23.0%	19.8%	23.5%	16.4%	18.6%	21.6%
■ Good	48.3%	49.3%	35.5%	41.7%	42.7%	38.1%	42.2%	36.6%	38.1%
■ Excellent	11.7%	13.5%	32.5%	23.2%	28.2%	21.2%	30.6%	28.8%	23.0%

   There is no readily apparent explanation for the relatively better conditions of some districts as compared to others. It may be possible to discern some reasons through analysis of schedule expenditures or mileages over the past few years. Note that Figure 7 includes pavements maintained by the Virginia Maintenance Services, Inc. (VMSI). In Figure 8 VMSI maintained lane miles have been removed such that the deficient mileages shown are all state maintained.

Figure 7: Deficient Lane Miles by District (2006)
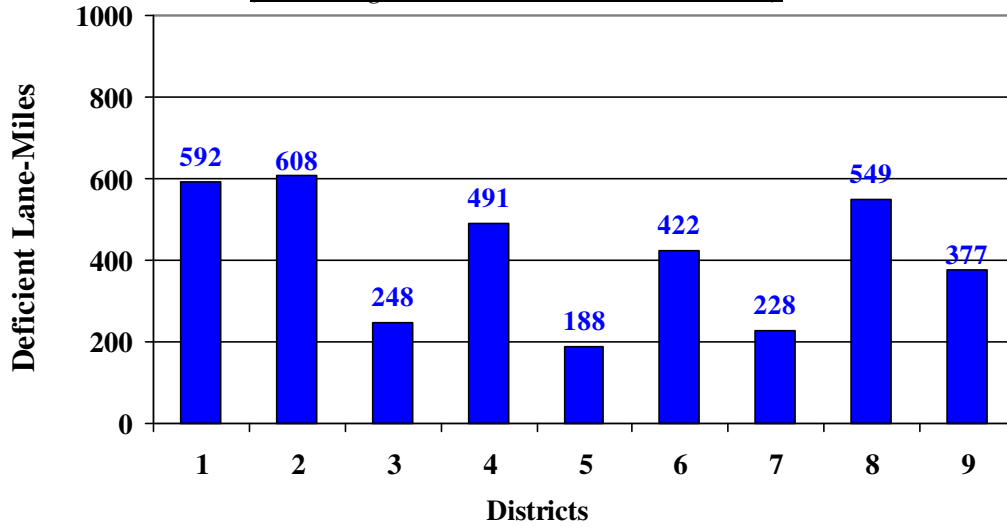*(Including VMSI Maintained Pavements)*

Figure 8: Deficient Lane Miles by District (2006)
(Excluding VMSI Maintained Pavements)
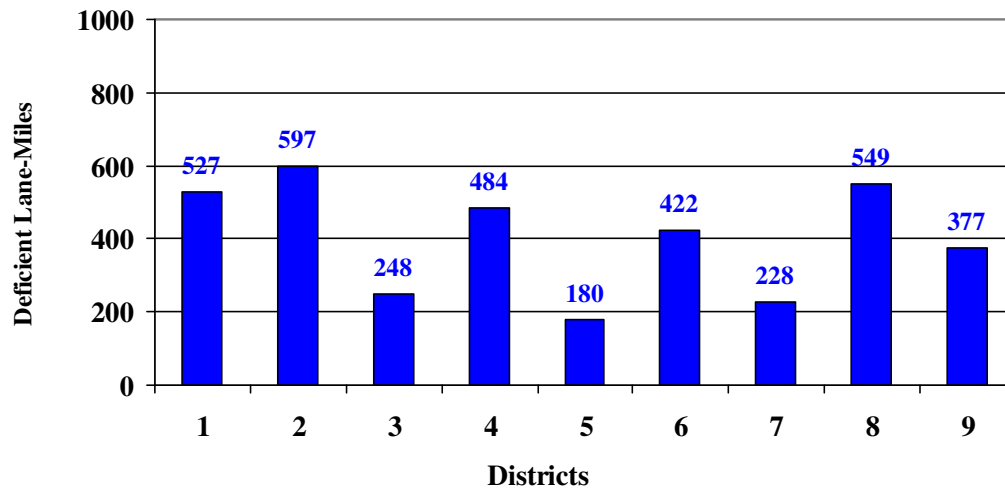
Figure 9 : Deficient Lane-Miles based on LDR and NDR

	1	2	3	4	5	6	7	8	9
■ Both	73	130	20	49	31	82	26	0	17
■ LDR only	514	411	221	269	110	188	190	549	339
■ NDR only	5	68	6	172	47	152	12	0	20
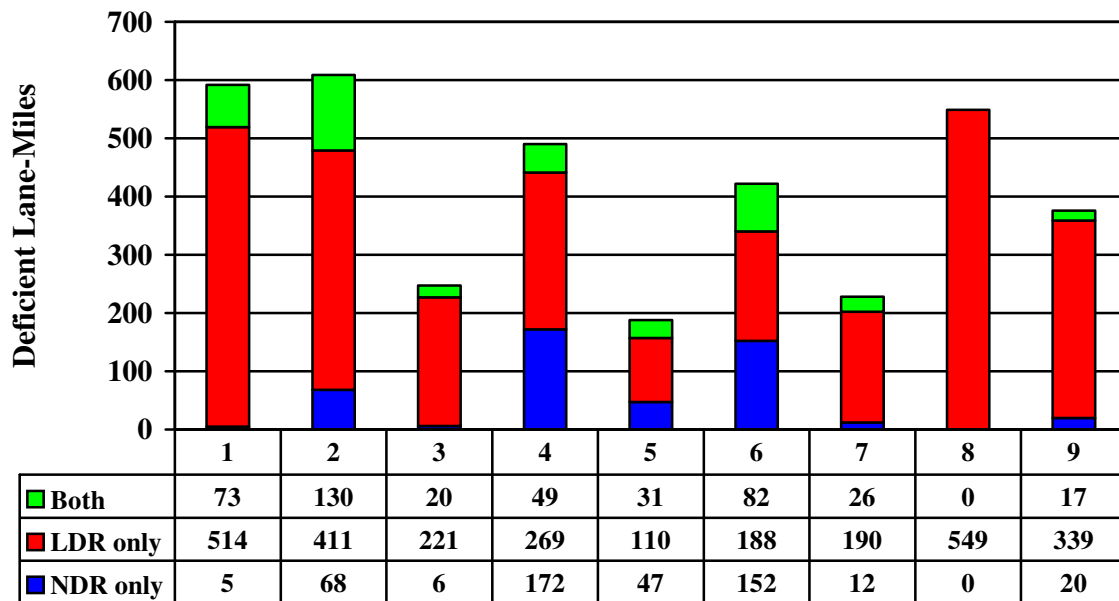
Figure 9 shows the distribution of the deficient lane-miles based on LDR or NDR among the districts. It is apparent that the load related distresses (i.e. truck loads) are the primary reasons for pavement distresses throughout the state. Non-load related distresses are mainly confined in districts 4 and 6. These districts have the old jointed concrete pavements that have been overlaid with asphalt, over the years. Reflection cracks over the joints, due to the movements of underlying slabs are the principal non-load related distress in these districts.

Figure 10 : Deficient Lane-Miles based on Route Type

	1	2	3	4	5	6	7	8	9
■ Primary	527	588	248	477	156	343	178	444	283
■ IS	65	21	0	14	33	78	50	105	94
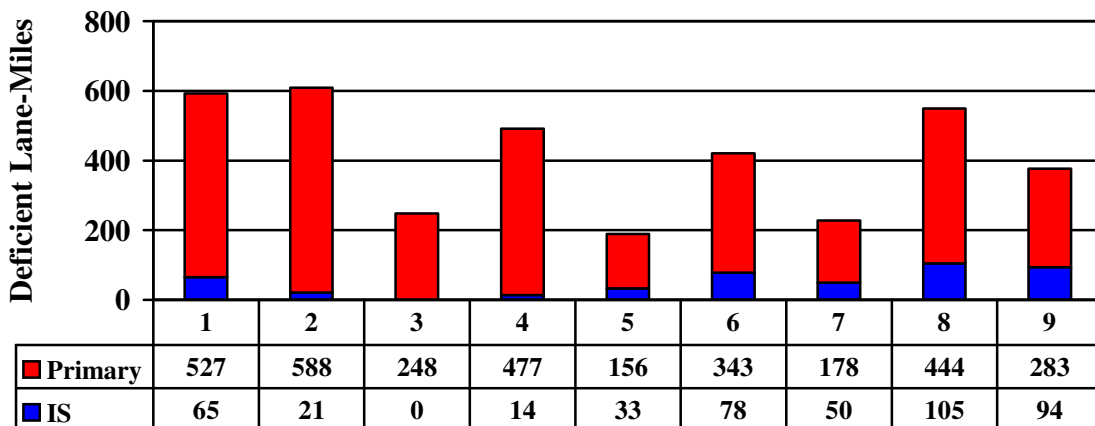
Figure 10 shows the distribution of deficient pavements based on route type (i.e. primary and interstate) among the districts. Districts 6, 8 and 9 have relatively higher number of deficient interstate lane-miles compared to the other districts. I-95 in districts 6 and 9 along with I-81 in district 8 are the main contributors of deficient mileages in this category. District 3, on the other hand, does not maintain any interstate.

THE CONDITION OF VIRGINIA PAVEMENTS BY COUNTY

Figure 11 is a map displaying pavement condition by county. The map gives the percentage of deficient pavements in each county within broad ranges as defined in the map. The deficient lane-miles range from zero in several counties to over 20% in 20. There are large variations between counties in every district so that there is no apparent pattern to where high or low deficiencies occur.

<u>Figure 11 : Pavement Condition by County</u>
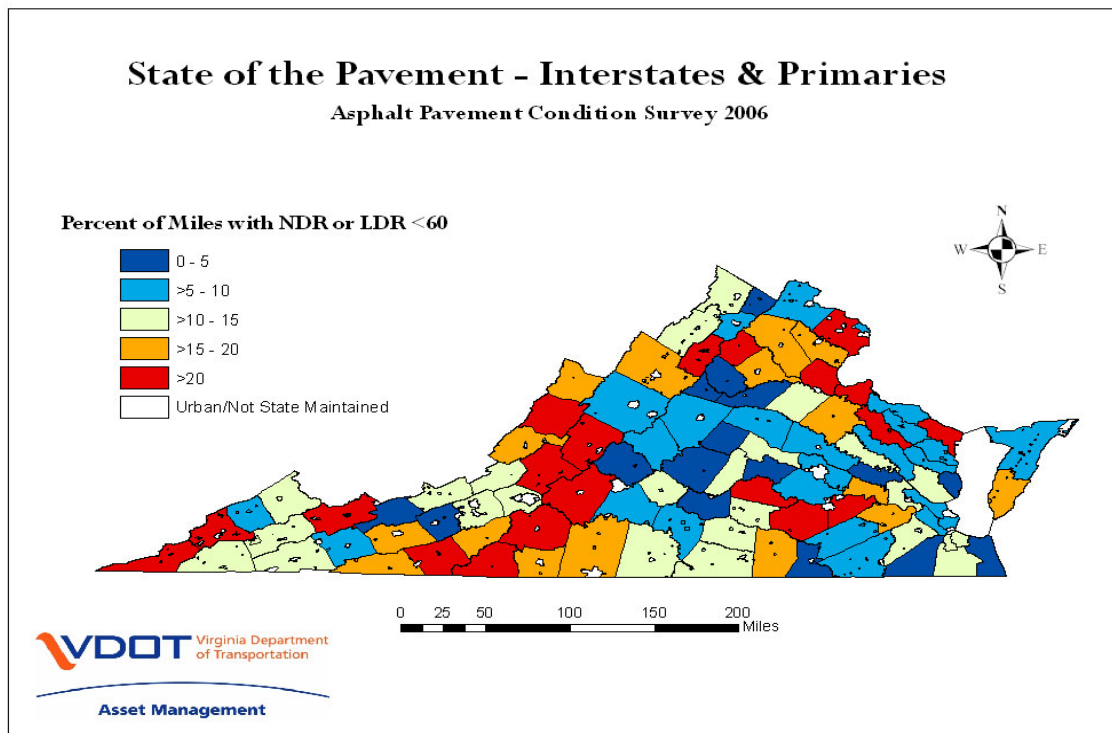
Appendix E provides a tabulation of Virginia pavement condition by district and by county. The county listings give the lane-miles rated in 2006 as well as the deficient lane-miles for interstate and primary pavement, using criteria discussed earlier. The tabulations should be useful to local managers in planning future work. In addition, district pavement management personnel have in their possession, all pavement ratings for their respective districts by County, Route, and homogeneous section.

USES & LIMITATIONS OF 2006 PAVEMENT CONDITION DATA

This section describes a few of the uses of this data as well as some of its limitations. In addition, future uses of this data are described here.

CURRENT USE OF THE DATA

With the 2006 data, the user may wish to look at the LDR and NDR separately as there are often different maintenance or rehabilitation treatments depending upon which types of distress are dominant. More specifically, it is likely that one would resurface or "mill and fill" a pavement with serious load related distress as such a pavement probably needs a minimum of some structural strengthening. In the case of non-load related distresses a preventive maintenance operation may be appropriate.

The windshield survey data is currently being used to feed the maintenance decision trees to determine the unconstrained requirements for the pavement assets in the Asset Management Division's needs-based analysis process.

PLANNING FOR MAINTENANCE AND RESURFACING

In prior years, windshield data have been used to aid in prioritizing Maintenance Resurfacing by the districts. Typically, the districts have used the data in combination with their local knowledge of pavement conditions to select pavement projects. Generally, pavements showing the greatest distress have been selected for repair.

PREVENTATIVE MAINTENANCE FUNDS ALLOCATION

The surface distress condition data captured in this windshield survey has been used to identify recommended candidate pavement sections for preventative maintenance activities. These recommendations have been done through the use of decision trees developed for the needs-based analysis.

LIMITATIONS OF THE DATA

While windshield survey data is very helpful in project selection it has limitations in determining what actually needs to be done to a pavement. Determining the appropriate action for a pavement that is not performing as well as desired may require the analysis of cores, trenching, and the use of non-destructive testing procedures. In other words, surface distress (especially premature) will indicate that something is wrong but can give no more than a hint as to what is wrong. For example, excessive early fatigue cracking suggests structural inadequacy, but does not indicate where the inadequacy lies (foundation, base, surface, etc.).

ACKNOWLEDGEMENTS

REFERENCES

1. A Guide to Evaluating Pavement Distress Through the Use of Digital Images, Virginia Department of Transportation, Asset Management Division, Apr. 2006.

2. McGhee, K H. 1984. Development of a Pavement Management System for Virginia: Final report on phase I: Application and Verification of a Pilot Pavement Condition Inventory for Virginia Interstate Flexible Pavements. VTRC Report No. 84-R21. Charlottesville: Virginia Transportation Research Council.

3. McGhee, K. H. 1987. *Status report: Implementation of a Pavement Management System in Virginia.* VTRC Report No. 87-R19. Charlottesville: Virginia Transportation Research Council.

4. *Pavement Maintenance Management for Roads and Streets Using the PAVER S*ystem, U.S. Army Corps of Engineers, Washington, D. C., 1990.

5. *Condition of the Pavement – 1998, Primary and Interstate Highways,* Virginia Department of Transportation, Maintenance Division, 1999.

6. *State of the Pavement – 2002, Interstate and Primary Highways,* Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2002.

7. *State of the Pavement – 2003, Interstate and Primary Highways,* Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2003.

8. *State of the Pavement – 2004, Interstate and Primary Highways,* Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2004.

APPENDIX A-REVIEW OF VDOT PAVEMENT CONDITION INDICES

The following provides a brief review of the pavement condition indices developed by VDOT over the past several years and applied to condition data collected with both automated and windshield survey means.

Pavement data consists of many different elements. In order to make effective use of such data, it is often convenient to combine and summarize those elements in a consistent and logical manner. Typically, converting the raw data into Condition Indices provides the desired organization. Expressing data as indices permits the consideration of different types of data (e.g. load and non-load related surface distress) with similar scales and similar action points. Indexing also combines data with similar impacts on pavement performance. These indices can then be treated as measures of pavement performance. They can be used to prioritize pavements for repair, trigger rehabilitation, predict future pavement performance and as a basis for the study of cost-effectiveness of repairs.

The Virginia Department of Transportation has used different measures of pavement condition (in the form of condition indices) for many years. In early Pavement Management there was a condition index describing pavement surface distresses detected through windshield surveys. This index called the Distress Maintenance Rating (DMR), supplemented by 'seat of the pants' evaluation of pavement ride quality, was used from the early 1980s through the early 1990s. Users applied the DMR and ride evaluation to the establishment of priority listings for plant mix overlays and to the allocation of funds for those overlays. In the mid-1990s VDOT began to collect pavement distress data through the use of videotaped images. To make use of data collected from those tapes VDOT also made interim use of the pavement condition index (PCI) defined and used by the U.S. Army Corps of Engineers and described in the July 1990 report entitled *Pavement Maintenance Management for Roads and Streets Using the PAVER System.* After several trial years, the PCI was deemed too general for Virginia conditions so that a VDOT specific method, as described below, was considered necessary.

Over the subsequent years VDOT undertook the development of a new set of pavement distress indices that focused on specific distress types and provided users with new pavement management tools. The new indices were defined on the basis of distress data collected automatically by videotape or by laser sensors mounted on the vehicle carrying the video recorders. The March 1998 Maintenance Division manual *A Guide to Evaluating Pavement Distress Through the Use of Video Images* was developed and used as the standard for the collection and evaluation of surface distress data.

The early 1980s approach was but a first step toward "true" pavement management because the DMR considered only surface distress and was not related to the various distress causes or to the consequences of those distresses and their causes in making pavement management decisions.   For example, one may need to address distresses related to wheel loads differently from those caused by weathering. Further, it is recognized by most pavement management systems that addressing the worst pavement first often is not the best use of available funds. It may at times be much more cost effective to repair a pavement in relatively good condition because that repair may

prolong the "remaining life" of the pavement far beyond the life expected if the same pavement was permitted to continue to deteriorate.

Fortunately, proper design and use of several different indices of pavement condition permit the pavement manager to identify those pavements that could benefit from early treatment. At the same time, those indices can indicate those pavements where deferred maintenance will not be overly detrimental or costly.

DESCRIPTION OF NEW CONDITION INDICES

One of the first steps in developing new indices was to identify the types of pavement condition issues that enter into maintenance and rehabilitation decisions. With input from the VDOT pavement management parameters committee it was concluded that there are three major classes of distress leading to most maintenance and rehabilitation decisions. These are cracking and other surface distress related to loads on the pavement, cracking and other surface distress related to environmental effects on the pavement surface, and the roughness (or smoothness) of the pavement surface. Load related distresses typically occur in the wheel paths while distresses relating to environmental factors may occur anywhere on the pavement surface.

Two new indices were defined. These are listed below while the components of each are summarized in Table A1:

- The load related distress index - **LDR**

- The non-load related distress index – **NDR**

Table A1: Distress Components of Individual Indices

INDEX	COMPONENTS
LDR	Alligator Cracking, Longitudinal Cracking in Wheel Paths, Potholes, Delaminations, Patching, Rutting
NDR	Block Cracking, Patching, Longitudinal Cracking outside the Wheel Path, Transverse Cracking, Reflection Cracking, Bleeding

This section provides a brief discussion of the practical implications of the various pavement condition indices and some ideas on how they may be applied in a typical pavement management decision-making process.

LDR – LOAD RELATED DISTRESS RATING

The LDR is an indication of pavement condition from the perspective of damage due to wheel loads applied to the pavement. A pavement with an LDR of 100 has no discernable load related distress. As a pavement wears and begins to show load related (wheel path) distress, the LDR begins to decrease. Unless a pavement is significantly under designed for the loads it carries the LDR will decrease very slowly for a fairly long period of time (usually 40 to 50 percent of the pavement's life) then will begin to decline

rapidly as the pavement becomes "fatigued". Ideally, major maintenance such as a structural overlay would be applied just before the rapid decline in LDR begins.

A pavement that is under designed or one that experiences a sudden significant increase in heavy axle loadings may be subject to early rapid decline in LDR. In any event of very rapid change in LDR a thorough analysis of the pavement is desirable. This can take the form of coring and materials testing, FWD tests, traffic analysis, or some combination of these actions to try to determine the cause of poor pavement performance. Failure to correct the cause of the rapid change in pavement condition may lead to a repeat of the same behavior.

Figure A1: A Load Related Distress (LDR) – Severe Alligator Cracks in both Wheel-paths

NDR – NON-LOAD RELATED DISTRESS RATING

Non-load related distresses could occur anywhere on the pavement surface and at any time. Some of these distresses are related to temperature and moisture changes in the pavement over time while some are related to other climate related issues such as oxidation of asphalt concrete, etc. Some non-load distress (e.g., reflection cracking) can be aggravated by wheel loads, but typically is not caused by those loads.

Non-load related distresses typically do not affect the whole pavement structure (i.e., they are usually superficial) and are much more likely to be treatable by less drastic actions than load related distresses. Slurry seals, chip seals, and very thin overlays often will work well on non-load related distresses. Composite pavements, however, may require thick overlays, milling and replacement, or even reconstruction to overcome the wide reflection cracks sometimes occurring.

Figure A2: A Non-Load Related Distress ⟨NDR) – Sealed Transverse

SIGNIFICANCE OF CONDITION INDEX RANGES

The condition indices were designed with Virginia conditions in mind. The design was kept consistent across all indices. The indices were designed to use the whole 0 – 100 scale. A pavement in need of rehabilitation should fall in the middle to lower end of this range i.e. 60 – 40 and below. Pavements in need of preventative maintenance should fall in the higher end of this scale i.e. 90 - 60. Of-course, decisions about type of repair need to be made by accounting for a myriad of factors including projected traffic loads, maintenance history of the pavement and materials used within the pavement structure.

The condition indices are based upon distress data only and do not in themselves provide a complete picture of the underlying pavement structure. That limitation has to be kept in mind whenever indices alone are used to trigger repair.

When the decision to repair is made solely on the basis of the amount of distress present on the pavement then the index ranges described above should provide good guidelines. This is due to the fact that the condition indices are based upon initial *Decision Trees* that were created as a part of initial PMP implementation. Decision Trees are a set of rules that specify when and what type of rehabilitation should be applied to a particular pavement. During PMP implementation the initial decision trees were created by a committee of experts within VDOT and reflected the accumulated consensus experience of VDOT on when and what type of repairs to apply to a pavement. Of-course, studying and codifying these rules was one of the major tasks within the Pavement Management Program. Thus, these decision trees were only an initial effort in this area and will continue to go through a series of iterations and research. However, the fact that the condition indices are based upon the decision trees means that as one is modified the other can also be changed. A typical initial Decision Tree is shown in figure A3. The use of this tree in designing the indices is described below:

> *As an example, consider the top line of the tree. It shows that if we are dealing with an Interstate pavement of PCI (overall condition index) greater than 70 but an IRI (International Roughness Index) of less than 150 then a Mill and Overlay Treatment is recommended. The condition numbers indicate that the pavement has little or no distress but is fairly rough. The assumption being that such a pavement does not suffer from structural problems thus a mill and overlay treatment would be sufficient to cure the roughness problem on this pavement. The Condition Indices were designed by taking into account the distress quantities shown in this tree. As an example, Box 12 shows that alligator cracking of 15% would cause a Mill and Overlay to be applied. The indices were designed in such a manner that they would result in a value of 50 (on a 0 – 100 scale) when 15% alligator cracking was encountered.*

Initial decision trees were explicitly included in the condition index design. Since these decision trees reflected expert opinion on VDOT repair and maintenance policies—the indices also reflected that opinion. In addition to using the initial decision trees to set the midpoint for the condition indices – other information sources (e.g. the experience of other agencies in tracking pavement deterioration) were also used to set how the indices transition from high to low values. The indices are set to transition smoothly from high to low values in a manner mirroring the deterioration of pavements over time. Table A2 shows the general index ranges:

Table A2: 1998 Index Ranges

	Type of Repair
0 – 30	Restorative
40 – 50	Partially Restorative
60 – 80	Partially Preventative
90 - 100	Do Nothing
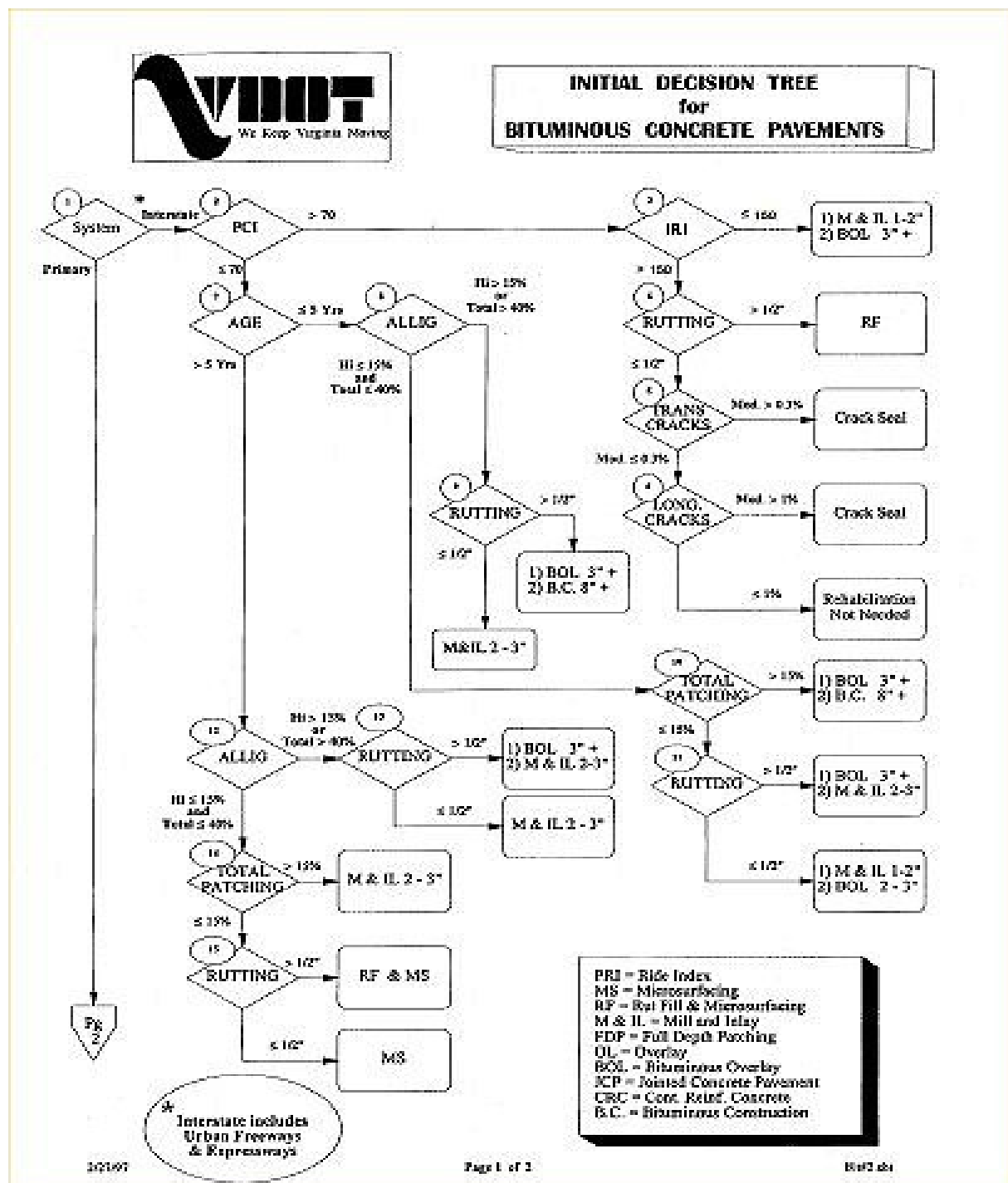
Figure A3: This decision tree was an initial attempt by a VDOT committee of experts to devise rules for when and what repairs should be carried out to Bituminous Surface Pavements. Information from this tree was used to design the new condition indices.

APPENDIX B-RATING FORM, RATING TEAMS

Rating Form
Asphalt Pavement Condition Windshield Survey

Rater		Date	

ID	District	County	Route	Route Dir	Lane Dir		Pavt Typ	Mix Typ	Last Rehab

Beg MP	Beg. Description	End MP	End Description	Length		# of Lanes	Divided

Distress		Frequency					Severity		
Alligator		None	Rare	Occasional	Frequent		NS	S	VS
Transverse (BIT)		Crack Count					NS	S	
Reflection (BOJ)		Crack Count					NS	S	VS
Rutting		None	Rare	Widespread			<1/2"	>1/2"	
Patches		None	Yes				<10%	>10%	

Comments:

28

Table B1 : Rating Team Makeup

District		Rating Team Members		"Round"
Bristol	1-C	8-E	2-E	B
Salem	2-C	8-C	1-C	A
Lynchburg	3-C	2-E	4-E	A
Richmond	4-C	5-C	9-C	B
Hampton Roads	5-C	7-S	6-E	A
Fredericksburg	6-C	4-C	9-C	A
Culpeper	9-E	6-C	4-E	B
Staunton	8-C	7-S	6-E	B
Nova	9-E	8-E	PMP-2	A

QA Team	1-E	3-E	

Chuck Ring	1-E	Wayne Carder	7-S
Mike Cole	1-C	Mary Budd	7-C
Clyde Landreth	2-E	Debbie Mintiens	8-E
Jeff Wright	2-C	Kevin Chisnell	8-C
Robert Wilson	3-E	Rob Wilson	9-E
Julius Monroe	3-C	Tom Layhue	9-C
William Hughes	4-E	Frank Brown	PMP-2
Lynn Huseby	4-C		
April Saunders	5-C		
Rick MacGregor	6-E		
Gary Murphy	6-C		

APPENDIX C: QUALITY ASSURANCE

Based on the statistical *"Central Limit Theorem"*, for a large population size, no matter what the population distribution is, a sample of thirty random test results is sufficient to characterize the parent population from which the sample comes and therefore to address quality assurance issues. A measure of how well the sample represents the parent population is to simply compare the sample and population averages. If they are close, the probability is high that the sample represents the population. In the context of the present work, the sample is the QA work for a district; the population is the production work for a district. While it would be possible to compare the sample and population directly, it is much more efficient for QA purposes to compare QA and production results on the same sites. That was the process followed in this work where at least 30 sites were randomly selected in each district and both QA and production results analyzed for each of those sites.

Quality assurance results for the 2006 windshield surveys are summarized in Table C1.   Bias between the production and QA teams was evaluated through a simple comparison of the average results for the two teams for the QA sample for each district. Note in Bristol that 52 sites comprised the QA sample. The average LDR for the QA and production teams was 71 and 69, respectively. Paired sample statistics showed that the difference is not significant at the 95% confidence level. Therefore, one can be 95% confident that there was no bias in the Bristol district LDR ratings. Similar results are seen for the NDR ratings. In fact, there was no statistically significant bias detected between any of the production teams and the QA team.

The measure chosen to evaluate "measurement error" between the QA and production teams was the "difference two standard deviation" (D2S) approach. The methodology involves the calculation of the average standard deviation of the differences between production and QA teams. Then, classical statistics says 95% of the differences can be expected to be within D2S of each other. For the Bristol district LDR ratings the D2S was 20.1, so that it can be concluded that if the same two teams rated the whole district, 95% of the paired ratings would be within 20 - 21 points. The same two teams would be expected to come within about 18 points on 95% of the sites for NDR ratings. To give a perspective on windshield data related to automated data, experience over the past few years has shown that automated data (pavement condition data collected digitally on videotapes by a data collection vendor and reduced manually) achieves a D2S of about 10 for LDR or NDR ratings. While it might be expected that windshield data could be even more variable. The detail results for 2006 QA data analyses are shown in the following table. As can be seen, the D2S could be as high as 21 points in case of LDR and 19 points in case of NDR Therefore, it can be concluded that for the 2006 windshield surveys, the production and QA teams compare as well as can be reasonably expected.

Table C1: 2006 Windshield Survey Quality Assurance

District	No. of Sites	LDR			NDR		
		Production	QA	D2S	Production	QA	D2S
1	52	69	71	20.1	88	92	18.4
2	54	78	77	18.8	88	91	12.3
3	55	81	82	16.5	93	94	12.9
4	49	77	76	17.5	86	89	18.6
5	48	86	85	14.9	92	90	13.4
6	57	75	73	18.7	86	87	18.0
7	56	79	80	15.5	95	96	14.9
8	54	77	77	19.9	94	92	13.0
9	47	76	74	19.8	91	89	16.9

APPENDIX D: INVENTORY EVALUATED

Table D1: Comparison of 'Official' VDOT Mileage (From Mileage Tables: December 31, 2004) and Windshield Survey (2006) Mileage, Based on Lane Miles

Dist.	Mileage (Lane Miles)						│Diff.│	│%Diff.│
	From Dec. 2004 Mileage Table (Excluding concrete mileages, as mentioned in VDOT website for GASB 34 compliance)			Windshield Miles Surveyed (2006)				
	IS	*PRI*	*Total*	*IS*	*PRI*	*Total*		
1	530.37	2932.48	3462.85	540.99	2904.28	3445.27	17.58	0.51%
2	487.62	2651.95	3139.57	491.44	2627.13	3118.57	21	0.67%
3	-	2607.42	2607.42	-	2702.33	2702.33	94.91	3.64%
4	885.98	3089.94	3975.92	913.67	3121.91	4035.58	59.66	1.50%
5	384.47	1544.32	1928.79	381.59	1647.67	2029.26	100.47	5.21%
6	279.6	2148.88	2428.48	280.53	2153.15	2433.68	5.2	0.21%
7	278.72	1843.12	2121.84	279.24	1807.36	2086.6	35.24	1.66%
8	937.35	2440.1	3377.45	948.14	2483.23	3431.37	53.92	1.60%
9	569.02	1516.98	2086	549.87	1619.03	2168.9	82.9	3.97%

APPENDIX E - 2006 PAVEMENT CONDITION BY DISTRICT AND COUNTY

District	County No.	County Name	Total Lane Miles Rated	Deficient Lane Miles	% Deficient
1	10	Bland	242.39	11.52	4.75%
	13	Buchanan	188.05	24.05	12.79%
	25	Dickenson	163.16	11.88	7.28%
	38	Grayson	234.6	38.48	16.4%
	52	Lee	305.34	74.5	24.40%
	83	Russell	291.94	37.86	12.97%
	84	Scott	285.73	28.62	10.02%
	86	Smythe	280.75	27.46	9.78%
	92	Tazewell	356.66	128.42	36.01%
	95	Washington	421.36	56.26	13.35%
	97	Wise	338.20	99.4	29.39%
	98	Wythe	337.09	53.3	15.81%
District 1 Total			*3445.27*	*591.75*	*17.18%*
2	9	Bedford	379.78	91.94	24.21%
	11	Botetourt	365.06	100.56	27.55%
	17	Carroll	309.62	68.94	22.27%
	22	Craig	119.32	16.38	13.73
	31	Floyd	109.6	19.94	18.19%
	33	Franklin	243.92	89.12	36.54%
	35	Giles	231.54	31.02	13.40%
	44	Henry	348.77	54.28	15.56%
	60	Montgomery	277.99	34.54	12.42%
	70	Patrick	231.04	59.94	25.94%
	77	Pulaski	181.25	7.26	4.01%
	80	Roanoke	320.68	34.43	10.74%
District 2 Total			*3118.57*	*608.35*	*19.51%*
3	5	Amherst	242.44	11.74	4.84%
	6	Appomattox	136.64	18.24	13.35%
	14	Buckingham	198.6	0	0%
	15	Campbell	316.23	26.36	8.34%
	19	Charlotte	260.83	17.72	6.79%
	24	Cumberland	104.78	12.22	11.66%
	41	Halifax	430.46	43.22	10.04%
	62	Nelson	257.52	23.78	9.23%
	71	Pittsylvania	537.11	86.74	16.15%
	73	Prince Edward	217.72	8.16	3.75%
District 3 Total			*2702.33*	*248.18*	*9.18*

District	County No.	County Name	Total Lane Miles Rated	Deficient Lane Miles	% Deficient
4	4	Amelia	114.62	23.84	20.80%
	12	Brunswick	332.92	61.96	18.61%
	18	Charles City	89.9	14.82	16.48%
	20	Chesterfield	545.4	35.45	6.50%
	26	Dinwiddie	248.53	79.53	32.00%
	37	Goochland	298.46	34.06	11.41%
	42	Hanover	371.98	21.97	5.91%
	43	Henrico	588.31	30.71	5.22%
	55	Lunenburg	126.98	19	14.96%
	58	Mecklenburg	489.29	69.07	14.12%
	63	New Kent	209.32	4.82	2.30%
	67	Nottoway	221.08	24.85	11.24%
	72	Powhatan	134.72	5.42	4.02%
	74	Prince George	264.07	65.24	24.71%
District 4 Total			*4035.58*	*490.74*	*12.16%*
5	1	Accomack	273.14	23.44	8.58%
	40	Greensville	149.68	0	0.00%
	46	Isle of Wight	206.46	28.94	14.02%
	47	James City	212.3	22.76	10.72%
	61	Nansemond	1.32	0	0.00%
	64	Norfolk	180.88	18.22	10.07%
	65	Northampton	158.02	25.14	15.91%
	75	Princess Anne	14.76	0	0.00%
	87	Southampton	229.54	12.9	5.62%
	90	Surry	97.85	17.2	17.58%
	91	Sussex	292.86	20.32	6.94%
	99	York	212.45	19.38	9.12%
District 5 Total			*2029.26*	*188.3*	*9.28%*
6	16	Caroline	383.87	73.99	19.27%
	28	Essex	172.36	66.6	38.64%
	36	Gloucester	184.98	22.1	11.95%
	48	King George	208.34	45.96	22.06%
	49	King & Queen	136.32	10.02	7.35%

District	County No.	County Name	Total Lane Miles Rated	Deficient Lane Miles	% Deficient
6	50	King William	109.32	11.28	10.32%
	51	Lancaster	125.82	11.82	9.39%
	57	Mathews	66.64	3.24	4.86%
	59	Middlesex	131.92	10.34	7.84%
	66	Northumberland	113.35	36.9	32.55%
	79	Richmond	107.84	9.74	9.03%
	88	Spotsylvania	289.97	32.19	11.10%
	89	Stafford	258.99	76.63	29.59%
	96	Westmoreland	143.96	10.84	7.53%
	District 6 Total		*2437.76*	*421.65*	*17.30%*
7	2	Albemarle	476.07	39.18	8.23%
	23	Culpeper	205.45	40.66	19.79%
	30	Fauquier	408.3	63.22	15.48%
	32	Fluvanna	102.2	0	0.00%
	39	Greene	86.43	1.74	2.01%
	54	Louisa	306.6	16.16	5.27%
	56	Madison	158.62	6.9	4.35%
	68	Orange	187.1	7.7	4.12%
	78	Rappahannock	155.83	52.56	33.73%
	District 7 Total		*2086.60*	*228.12*	*10.93%*
8	3	Alleghany	323.75	57.92	17.89%
	7	Augusta	560.66	42.26	7.54%
	8	Bath	149.96	43.08	28.73%
	21	Clarke	149.62	5.16	3.45%
	34	Frederick	449.7	65.74	14.62%
	45	Highland	141.16	21.28	15.08%
	69	Page	149.48	35.04	23.44%
	81	Rockbridge	471.24	122.98	26.10%
	82	Rockingham	532.13	103.3	19.41%
	85	Shenandoah	354.88	38.36	10.81%
	93	Warren	148.79	13.95	9.38%
	District 8 Total		*3431.37*	*549.07*	*16.00%*
9	0	Arlington	234.89	18.62	7.93%
	29	Fairfax	1082.41	238.28	22.01%
	53	Loudoun	384.61	36.21	9.41%
	76	Prince William	466.99	83.6	17.90%
	District 9 Total		*2168.90*	*376.71*	*17.37%*
Statewide			25451.56	3702.87	14.55%